

EFFECT OF SUBSTRATE, REDOX MEDIATOR AND AERATION ON
BIOGRANULATION TREATMENT OF TEXTILE WASTEWATER

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ABSTRACT

Wastewater discharged by dye manufacturing and textile industries has become a major environmental concern. The treatment of textile wastewater is important and has been an issue due to the toxicity of the wastewater and aesthetic impact on water sources. One of the alternatives in treating textile wastewater is by using biological treatment via biological granulation method. Biogranulation treatment strategy based on anaerobic reduction of the azo dyes, followed by aerobic transformation of the formed aromatic amines, holds promise. The *biogranulation* process of textile dyeing wastewater and its performance in terms of COD and color removal can be influenced by many factors. Among them, substrate (electron donor), redox mediator and aeration time were identified as factors that may give effect on the rate of COD removal and dye degradation process. This research is aimed at optimising these factors. Research was conducted in a batch test with the hydraulic retention time of 24 hours. Glucose, sodium acetate and methanol were used as the different substrates with concentrations of 1000, 2000 and 3000 ppm. Glucose with concentration of 3000 ppm was the preferred among the substrate tested with COD removal of 65.2 % and color removal of 84%. Riboflavin was used as the *redox mediator* with concentrations of 1, 2 and 3 μM and concentration of 2 μM was preferred among the other concentrations with COD removal of 50.8 % and color removal of 87.9 %. Three anaerobic-aerobic reaction time models were tested, namely, 23:1, 21:3 and 7:17. Among them, model 7:17 had the highest COD removal of 93.4 % and model 21:3 has the highest color removal of 90.9 %. The effect of three factors mentioned was verified through an *analysis of variance* (ANOVA).

ABSTRAK

Pembuangan air sisa yang dilepaskan oleh industri pembuatan pewarna dan tekstil telah menjadi penyumbang utama kepada kualiti alam sekitar. Sumber air sisa daripada industri tekstil penting untuk dirawat disebabkan oleh kadar toksik air sisa dan kesan estetik ke pada sumber air. Satu alternatif dalam merawat airsisa tekstil ialah dengan menggunakan rawatan biologi melalui kaedah penggranulan biologi. Strategi rawatan penggranulan-bio berdasarkan pengurangan pewarna azo secara anaerobic, diikuti oleh penyingkiran aerob amina aromatik kepada yang telah terbentuk. Proses penggranulan-bio untuk airsisa tekstil dan prestasinya dalam penyingkiran COD dan warna dipengaruhi oleh beberapa faktor. Substrat (penderma elektron) kehadiran pengantara redoks dan masa pengudaraan dalam fasa tindak balas aerob dikenal pasti sebagai faktor-faktor yang boleh memberi kesan kepada kadar proses penyahhidratan pewarna. Penyelidikan ini bertujuan untuk mengoptimumkan faktor-faktor ini. Penyelidikan dijalankan dalam ujian berkelompok dengan tempoh tahanan hidraulik (HRT) dua puluh empat jam. Glukosa, natrium asetat dan metanol telah digunakan sebagai penderma-penderma elektron pada kepekatan 1000, 2000 dan 3000 ppm. Glukosa dengan kepekatan 3000 ppm memberi hasil yang terbaik dengan penyingkiran COD 65.2 % dan penyingkiran pewarna 84%. Riboflavin telah digunakan dengan kepekatan redox mediator 1, 2 dan 3 μM dan kepekatan 2 μM adalah yang terbaik dengan penyingkiran COD 50.8 % dan penyingkiran pewarna 87.9 %. Tiga model masa tindak balas anaerob-aerob telah diuji iaitu 23:1, 21:3 dan 7:17. Model 7:17 mempunyai penyingkiran COD tertinggi iaitu 93.4 % dan model 21:3 mempunyai penyingkiran pewarna tertinggi iaitu 90.9 %. Kesan ketiga tiga faktor tersebut telah dibuktikan melalui analysis of variance (ANOVA).

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




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LIST OF ABBREVIATIONS

ADMI	-	American Dye Manufactures Index
ANOVA	-	Analysis of Variance
AOX	-	Absorbable Organic Halide
APHA	-	American Public Health Association
BOD	-	Biological Oxygen Demand
CaCl	-	Calcium Chloride
COD	-	Chemical Oxygen Demand
DLVO	-	Derjaguin and Landau, Verwey and Overbeek
EDTA	-	Ethylene Diamine Tetraacetic Acid
HPLC	-	High Performance Liquid Chromatography
HRT	-	Hydraulic Retention Time
K ₂ HPO ₄	-	Dipotassium hydrogen phosphate
KH ₂ PO ₄	-	Potassium dihydrogen phosphate
MgSO ₄	-	Magnesium Chloride
N	-	Nitrogen
NH ₄ Cl	-	Ammonium Chloride
P	-	Phosphorus
SBR	-	Sequencing Batch Reactor
TOC	-	Total Organic Carbon
UASB	-	Up-flow Anaerobic Sludge Blanket
UV	-	Ultra Violet

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CHAPTER 1

INTRODUCTION

1.1 Background

Dyes are one of the most demanding compounds in many industries such as rubber, paper, plastic, cosmetic, etc. However the biggest consumer of dyes are textile industries. It is estimated that about 10,000 of different commercial dyes and pigments exist and over 7×10^5 tonnes are produced annually world wide (Pearce *et al.*, 2003 and Yu *et al.*, 2010). Among them azo dyes are the largest group of synthetic dyes (60–70%). A small amount of azo dye in water (10–50 mg/L) is highly visible (Carliell *et al.*, 1995). With enormous demand and consumption of dyes, treatment of textile dyeing wastewater is a big issue.

Textile wastewater generated from different stages of textile processing that contains various toxicants, dye stuff and pollutants which are harmful to the natural aquatic environment when released without proper treatment. Textile wastewater increases the chemical oxygen demand (COD), biological oxygen demand (BOD), solid content, toxicity and the color of the aquatic environment. As dyes are designed to be chemically and photolytically stable, they are highly persistent in natural environments. The release of dyes may therefore present an ecotoxic hazard and

introduces the potential danger of bioaccumulation that may eventually affect man by transport through the food chain. Stringent legislation on discharge as per the requirement of Environmental Quality Act of Malaysia (EQA) and other developed countries give further challenges to the industry. Thus, there is a need for continues study and research on the wastewater treatment to find new methods of treatment in order to protect the environment.

1.2 Problem Statement

Textile processes produce wastewater which could be difficult to be treated (O'Neill *et al.*, 2000). This wastewater can cause serious environmental problems due to their high color, large amount of suspended solids, and high chemical oxygen demand (Kim *et al.*, 2004). Standard discharge limits of textile effluent are becoming more stringent in recent days creating continuous problems for industries to reach the compliance level.

There are a number of techniques for treating textile wastewater. The main methods are physical and chemical processes which include flocculation, coagulation, adsorption, reverse osmosis and chemical oxidation. Although these techniques have color removal capabilities, their application is limited due to several disadvantages. In coagulation process, large amount of sludge is created which may become a pollutant itself and increase the treatment costs. Oxidation process such as ozonation effectively decolorises almost all dyes except disperse dyes but does not remove COD effectively (Ahn *et al.*, 1999). Electrochemical oxidation produce pollutants which increases the treatment costs (Kim *et al.*, 2003). Other means of dye removal such as chemical oxidation, coagulation and reverse osmosis are generally not feasible due to economic constraint (Ghoreishi and Haghighi, 2003 and Lu *et al.*, 2010).

Conventional biological methods are generally cheap and simple to apply and are currently used to remove organics and color from dyeing and textile wastewater. However this wastewater cannot be readily degraded by conventional biological processes because the structure of most azo dyes are generally complex and many of them are non biodegradable due to the chemical nature and molecular size (Kim *et al.*, 2004). Aromatic amines that are produced after the anaerobic degradation of N=N bond of azo dyes, are generally more toxic than the primary compounds (Hailei *et al.*, 2006).

Studies have shown that both anaerobic and aerobic biological treatments are required to complete the mineralization of dye compounds and remove organics. Through the sequencing of both processes, complete mineralization of dye and organic removal could be achieved. The former would cause the cleavage of the azo bond. The latter performs complete mineralization of the dye compounds to form harmless and stable byproducts (Isik and Sponza, 2005).

At present, the use of aggregated microorganisms in comparison with suspended cells is more attractive. These microorganisms can form granules through cell-to-cell interaction or in combination with other particulates. The granular system has some advantages such as good settling ability, high concentration of microorganisms with strong and compact structure and high biomass retention that could withstand significantly higher organic loading (Morgenroth *et al.*, 1997 and Moy *et al.*, 2002). With such characteristics, the granular system has great advantages as compared to the conventional activated sludge system.

There are some parameters that may affect textile wastewater treatment such as the composition and concentration of substrate, concentration of redox mediator as the accelerating agent and aeration time (Dos Santos *et al.*, 2003 and Isik and Sponza, 2005). The aim of this study is investigate the effect of above parameters on treating textile wastewater using biogranular sludge biomass.

1.3 Objectives of the Study

The specific objectives of this study are:

- i. To investigate the effect of different compositions and concentrations of substrate on the performance of biogranules in terms of COD and color removal on textile dyeing wastewater.
- ii. To investigate the effect of different concentrations of redox mediator on the performance of biogranules in terms of COD and color removal on textile dyeing wastewater.
- iii. To investigate the effect of different aeration times on the performance of textile dyeing wastewater.

1.4 Scope of the Study

This study covers the application of batch test using granular sludge for treating synthetic textile dyeing wastewater. The performance of the granular sludge in treating textile dyeing wastewater was investigated. The effects of different compositions and concentrations of substrate, redox mediator and aeration times on COD and color removal are investigated.

1.5 Significance of the Study

Biogranular systems have been studied for the degradation of different types of wastewater (Beun *et al.*, 1999; Hailei *et al.*, 2006; Ji *et al.*, 2010 and Moussavi *et al.*, 2010). The applications of granular system in treating textile wastewater have been reported by many researchers (Razo-Flores *et al.*, 1997 and Dos Santos *et al.*, 2003). Apparently, studies on the parameters that affect the performance of textile wastewater treatment appear to be missing. Hence, more research needs to be conducted in this area to provide a better understanding on the capability of the treatment system. The importance of this study is therefore listed as follow:

1. The study provides the understanding on the effect of using different compositions and concentrations of substrate in relation to the dye degradation by the biogranules.

2. The study provides the understanding on the effect of using different concentrations of redox mediator in relation to the dye degradation by the biogranules.

3. The study provides the understanding on the effect of using different aeration times in relation to the dye degradation by the biogranules.

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